Trajectory of functional outcome and health status after moderate-to -major trauma in Hong Kong: A prospective 5 year cohort study

T.H. Rainer, K.K.C. Hung, J.H.H. Yeung, S.K.C. Cheung, Y.K. Leung, L.Y. Leung, W.B. Goggins, H.F. Ho, C.W. Kam, N.K. Cheung, C.A. Graham

Accident and Emergency Medicine Academic Unit,
Chinese University of Hong Kong, Hong Kong

School of Medicine, Cardiff University,
United Kingdom

Trauma & Emergency Centre, Prince of
Wales Hospital, Hong Kong

JC School of Public Health and Primary
Care, Chinese University of Hong
Kong, Hong Kong

Accident and Emergency Department,
Queen Elizabeth Hospital, Hong Kong

Accident and Emergency Department, Tuen Mun Hospital, Hong Kong

ABSTRACT

Background: Trauma care systems in Asia have been developing in recent years, but there has been little long-term outcome data from injured survivors. This study aims to evaluate the trajectory of functional outcome and health status up to five years after moderate to major trauma in Hong Kong. Methods: We report the five year follow up results of a multicentre, prospective cohort from the trauma registries of three regional trauma centres in Hong Kong. The original cohort recruited 400 adult trauma patients with ISS _ 9. Telephone follow up was conducted longitudinally at seven time points, and the extended Glasgow Outcome Scale (GOSE) and Short-Form 36 (SF36) were tracked.

Results: 119 out of 309 surviving patients (39%) completed follow up after 5 years. The trajectory of GOSE, PCS and MCS showed gradual improvements over the seven time points. 56/119 (47.1%) patients reported a GOSE = 8 (upper good recovery), and the mean PCS and MCS was 47.8 (95% CI 45.8, 49.9) and 55.8 (95% CI 54.1, 57.5) respectively at five years. Univariate logistic regression showed change in PCS - baseline to 1 year and 1 year to 2 years, and change in MCS - baseline to 1 year were associated with GOSE = 8 at 5 years. Linear mixed effects model showed differences in PCS and MCS were greatest between 1-month and 6-month follow up.

Conclusions: After injury, the most rapid improvement in PCS and MCS occurred in the first six to 12 months, but further recovery was still evident for MCS in patients aged under 65 years for up to five years.

Introduction

The current worldwide trend to implement trauma systems has aimed to improve survival, health status, and functional outcome in trauma patients, and there is good evidence that this has effectively reduced mortality after trauma. Increased survivorship has led to an increased emphasis on the evaluation and

improvement of the functional outcome of survivors. Globally, injuries accounted for 10.1% of disability-adjusted life years in 2015. An evaluation of functional recovery and quantification of the long-term burden of injury-related disability burden of non-fatal trauma is important. Studies on injury-related disability burden may help to identify predictors of long-term health outcome, inform research on early treatment to minimize the development of secondary health conditions that may arise after long-term disability. Serious orthopaedic injuries have been found to be associated with lifestyle changes including low physical activity levels and highly sedentary behaviours, which is itself detrimental to health outcomes. Generic health status measures such as SF-36 provide standardised matrices to measure the individual recovery trajectory, and quantify health status across injury sites and types as compared to population norm. It also allows evaluation of long-term trauma outcomes across different settings, which may highlight gaps for improvement.

Most of the studies measuring generic health status of a general trauma population at various time points only followed up the patients within 2 years post-injury. A few longer term studies with multiple follow-up assessments showed significant changes in health status continue from 2 years and up to 10 years post injury. Studies on traumatic brain injury also suggested that certain aspects of functional recovery may continue to change beyond 2 years. Hong Kong has a relatively new trauma system which was established in 2006. The performance of our system has been shown to be comparable to international standards. We have previously published one-year follow up data from this multi-centre cohort. There is little or no data in Chinese patients for long-term recovery for up to five years after moderate and severe trauma. The current study aims to evaluate the trajectory of trauma patient recovery from three major trauma centres in Hong Kong over a five-year period.

Methods

Study design

This is a prospective five-year cohort study of trauma patients admitted to three of the five major trauma centres in Hong Kong. Ethical approval was obtained from the local ethics review board. The summary of this cohort of 400 patients has been previously described [27,28]. The Prince of Wales Hospital (PWH), Queen Elizabeth Hospital (QEH) and Tuen Mun Hospital (TMH) are all regional trauma centres in Hong Kong serving the New Territories East, Kowloon Central and the New Territories West of Hong Kong.

Patients, inclusion and exclusion criteria

In summary, adult patients aged 18 years with moderate or major trauma (defined as an ISS 9) who were entered into the trauma registry were included. The trauma registry included trauma patient triaged as critical or emergency, patients admitted to the intensive care unit and trauma deaths. A record was kept of all patients who were not enrolled and also of the reasons for exclusion.

Table 1 Baseline clinical characteristics and trauma data of 400 patients with moderate and severe trauma from 3 trauma centres.

	All patients (N = 400) [a]	Surviving respondents (N = 119) [b]	Surviving non-respondents (N = 190) [c]	Death (N = 91) [d]	P value [b] vs. [c]
Age	53.3 (20.2)	47.7 (17.7)	49.4 (19.0)	68.8 (18.3)	0.45[a]
Male	278/400 (69.5%)	90/119 (75.6%)	131/190 (68.9%)	57/91 (62.6%)	0.21[b]
Mechanism of injury					
Road traffic accident	127/400 (31.8%)	42/119 (35.3%)	71/190 (37.4%)	14(15.4%)	0.22[b]
Penetrating	22/400 (5.5%)	4/119 (3.4%)	17/190 (8.9%)	1 (1.1%)	
Fall < 2 meters	154/400 (38.5%)	38/119 (31.9%)	55/190 (28.9%)	61 (67.0%)	
Fall 2 meters	48/400 (12.0%)	21/119 (17.6%)	22/190 (11.6%)	5 (5.5%)	
Others	49/400 (12.3%)	14/119 (11.8%)	25/190 (13.2%)	10 (11.0%)	
Polytrauma	261/400 (65.3%)	70/119 (58.8%)	117/190 (61.6%)	74/91 (81.3%)	0.60[b]
ISS					
<15	139/400 (34.8%)	49/119 (41.2%)	73/190 (38.4%)	17 (18.7%)	0.045[b]
16-24	132/400 (33.0%)	32/119 (26.9%)	75/190 (39.5%)	25 (27.5%)	
25	129/400 (32.3%)	38/119 (31.9%)	42/190 (22.1%)	49 (53.8%)	
Ps					
0.75	34/391 (8.7%)	6/117 (5.1%)	7/186 (3.8%)	21 (24.1%)	0.82[b]
0.76-0.95	135/391 (34.5%)	34/117 (29.1%)	52/186 (28.0%)	49 (56.3%)	
0.96-1.00	222/391 (56.8%)	77/117 (65.8%)	127/186 (68.3%)	17 (19.5%)	
RTS					
6.0	42/399 (10.5%)	5/119 (4.2%)	9/190 (4.7%)	28 (31.1%)	0.92[b]
6.01-7.84	53/399 (13.3%)	18/119 (15.1%)	26/190 (13.7%)	9 (10.0%)	
7.8404	304/399 (76.2%)	96/119 (80.7%)	155/190 (81.6%)	53 (58.9%)	
Trauma call activation	162/399 (40.6%)	45/118 (38.1%)	86/190 (45.3%)	31 (34.1%)	0.22[b]
ICU admission	151/398 (37.9%)	42/118 (35.6%)	68/189 (36.0%)	41 (45.1%)	0.95[b]
Operation	179/397 (45.1%)	51/118 (43.2%)	87/189 (46.0%)	41 (45.6%)	0.63[b]
LOS in ICU (IQR)	3.0 (2.0-8.0)	3.0 (1.4-6.0)	2.3 (2.0-5.8)	6.0 (2.0-11.5)	0.90[c]
Total LOS (IQR)	10.0 (4.9-20.8)	9.7 (6.0-20.5)	10.0 (4.8-20.5)	10.5 (3.2- 23.69)	0.63[c]

ISS: injury severity score; Ps: probability of survival; RTS: revised trauma score; LOS: length of stay in days; IQR: interquartile range. a Student t-test. b Chi square test. c Mann-Whitney U test.

Measurements and data collection

Patients were recruited during their initial acute hospital admission, and followed up at regular time points post injury (1 month, 6 months, 1 year, 2 years, 3 years, 4 years and 5 years) by telephone interviews. At five years post injury, standardised questionnaire using the primary outcomes of extended Glasgow Outcome Scale (GOSE) and the Short-Form 36 (SF36) health status tool was evaluated at the seven time points. Demographic data included age, sex, and mechanism of injury, Injury Severity Score (ISS), Revised Trauma Score (RTS), probability of survival (Ps), Glasgow Coma Scale (GCS), hospital and ICU length of stay (LOS) and contact information were extracted from the trauma registry and patients' records. Follow up assessments involved two strategies. Firstly, the survival status (alive/ dead) of subjects were retrieved from the centralised, computerised medical data system of the Hospital Authority. The computerised medical system captures clinical information for all patients who has visited the public health services in Hong Kong. Subjects who died will be updated in the system regularly, and this information was accurate and reliable for research purposes. The other categories of GOSE and the SF 36 were determined by phone interviews, either with the injured individual or by proxy carers. The researchers made up to five attempts to contact the patient by telephone and to conduct a questionnaire interview.

Statistical analysis

Descriptive statistics were presented in mean and standard deviation or median and interquartile range wherever appropriate. The baseline characteristics of the surviving respondents and the surviving non-respondents were compared using t-test for normally distributed variables. Those survivors who did not provide a response at the 5 year follow up were defined as non-respondents, regardless of whether they have completed all previous follow ups. Continuous variables with a skewed distribution were tested by Mann-Whitney U test. Association between the groups was tested by chi square test. Associations between explanatory factors and functional outcome of upper good recovery (GOSE = 8) were examined by univariate logistic regression. Linear mixed effects model (LMM) analyses were performed to assess the changes in Physical Component Summary (PCS) and Mental Component Summary (MCS) over various time points. The interaction between 1) age and time; 2) gender and time; 3) ISS and time for PCS and MCS were also assessed using LMM. Deaths and loss to follow up were excluded from the GLMM and the LMM analyses. All statistical analyses were performed using SPSS version 23 (IBM Corp, Armonk, NY).

Results

Table 1 shows the characteristics of the initial cohort of 400 patients (mean age 53.3 years; 69.5% male), including five-year deaths (n = 91), and surviving respondents and surviving non-respondents. Fig. 1 shows the detailed flow of patients, including those who died and lost to follow up at the various time points. At 5 years, there were 309 survivors of whom 119/309 (39%) completed follow up. Proxy was used in 5–20% of the response over various time points (Supplementary 1). There were no statistically significant differences between surviving responders and non-responders in terms of the baseline characteristics, except the distribution of ISS (Table 1). There was a higher proportion of surviving non-responders with an ISS between 16–24 compared with surviving responders.

GOSE and SF36 at five years post injury

Fig. 2 shows the distribution of GOSE categories at the various time points. At five years, 56/119 (47.1%) cases reported GOSE = 8 (upper good recovery) whilst 67/119 (56.3%) cases had reached GOSE = 7 (good recovery) meaning a state of independence at home or outside. For the SF36, the mean PCS was 47.8 (95% CI 45.8, 49.9) and the mean MCS was 55.8 (95% CI 54.1, 57.5) at 5 years post injury.

.

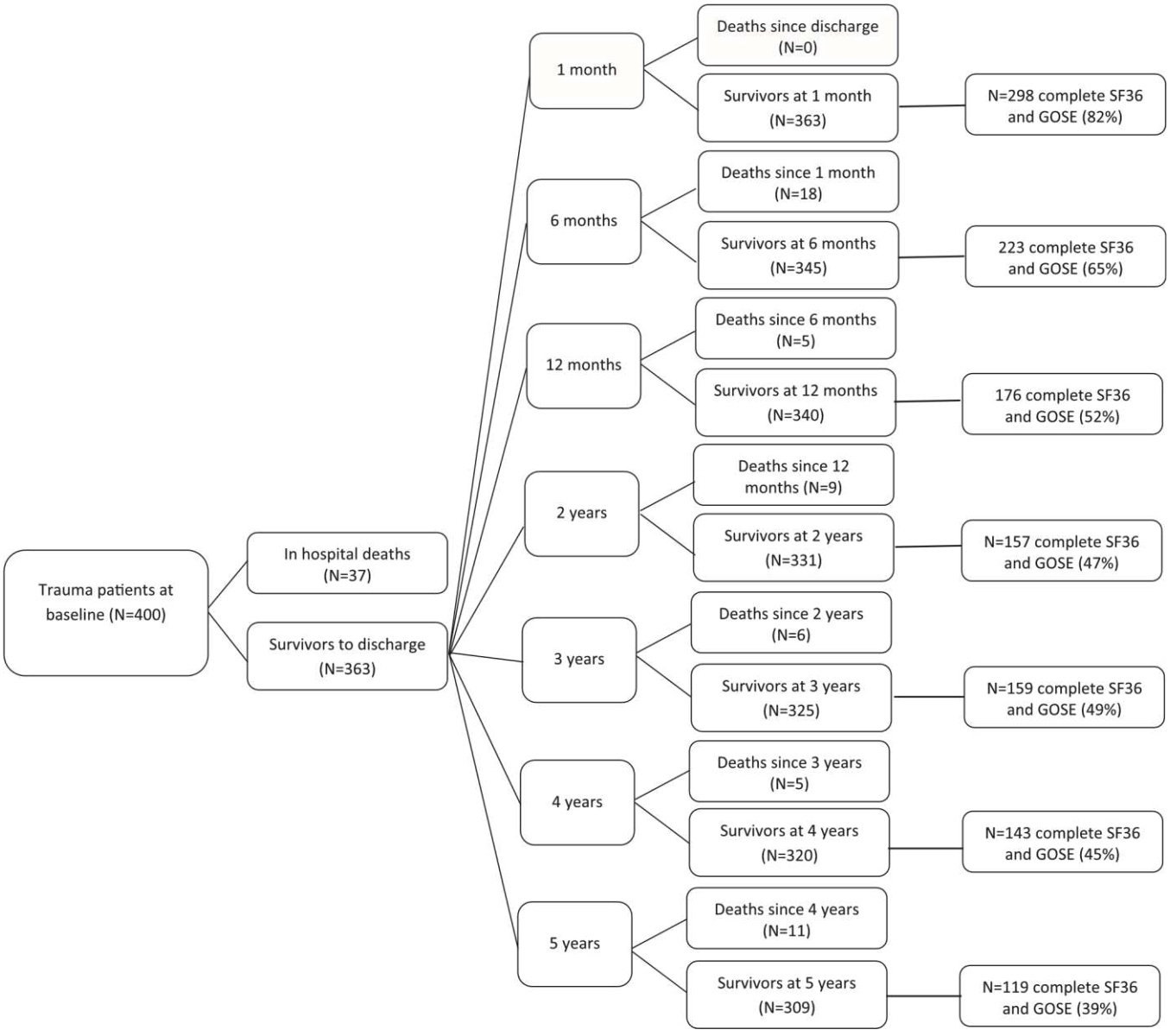

Fig. 1. Flow of participants through the study.

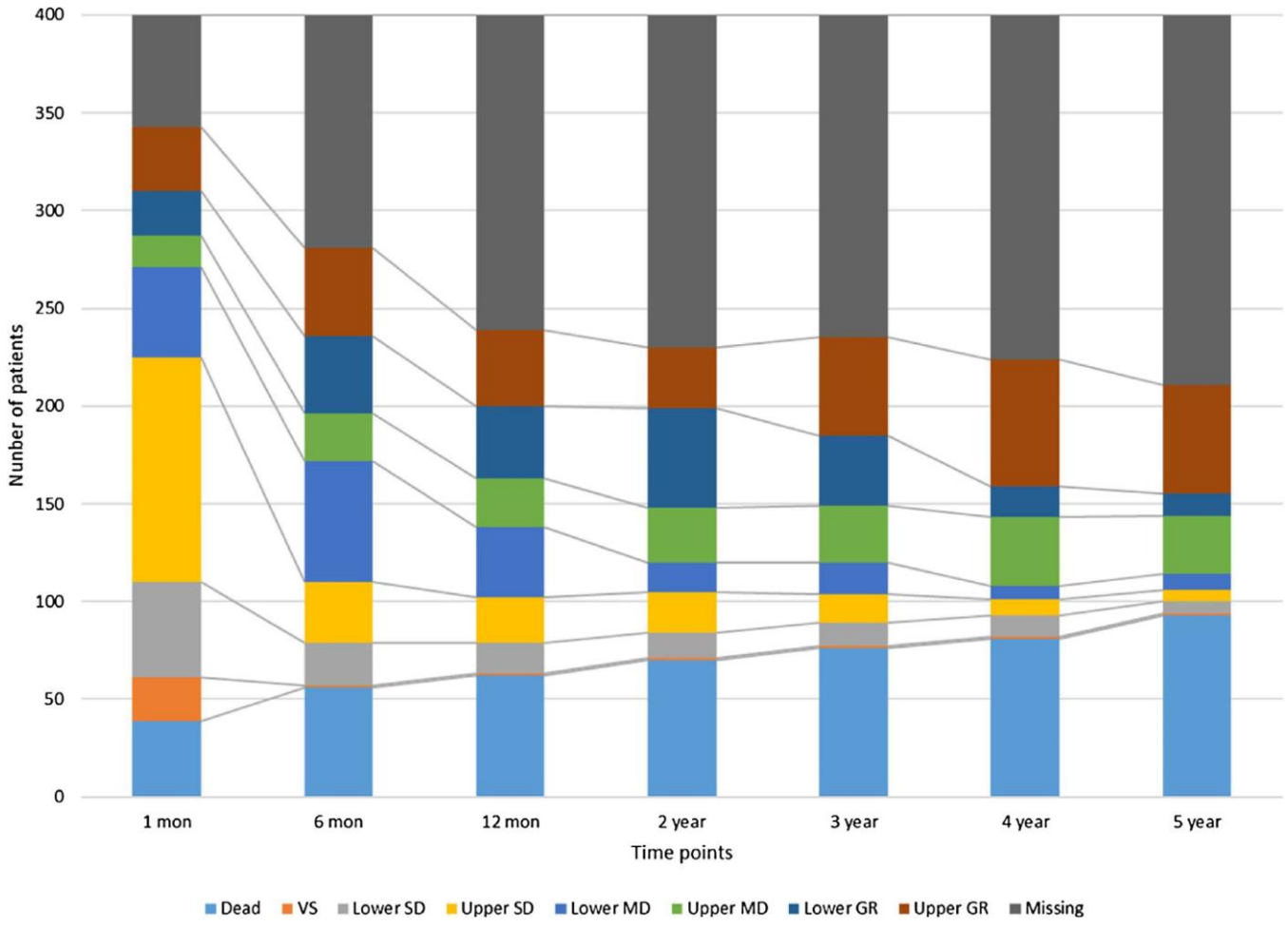

Fig. 2. Changes in distribution of functional outcome by GOSE over time (n = 400).

Variables associated with upper good recovery (GOSE = 8) at 5 years

Table 2 showed change in PCS (1 year – baseline) and PCS (2 year – 1 year), and change in MCS (1 year – baseline) were associated with upper good recovery at 5 years using univariate logistic regression.

Trajectory of PCS and MCS of SF36

LMM showed the MCS continued to improve over 5 years, with statistically significant difference between 1–6 month FU (mean difference of 6.5 with 95% CI 3.9, 9.0). For the PCS the mean difference continued to be positive for up to 2 years, with statistically significant differences between the 1–6 month FU, and the 6–12 month FU. The mean differences, however, was 4.3 (95% CI 2.1, 6.4) for 1–6 month and 2.5 (95% CI 1.1, 3.8) (Table 3). Fig. 3 and Supplementary 2,3 show graphical presentation of physical (PCS) and mental component score (MCS) by age, gender and ISS. LMM analyses showed interaction by age group over time (age below 65 vs age _65) was non-significant for PCS (β 4.25; 95% CI -0.74, 9.23; p = 0.10) but statistically significant for MCS (β 7.50; 95%CI 2.26, 12.74; p = 0.01) (Fig. 3). Fig. 3 showed a decline in MCS for older patients after two years, while younger patients showed a steady improvement over the study period. For interaction by gender over time both PCS (β _1.81; 95%CI _6.52, 2.90; p = 0.45) and MCS (β 2.49; 95%CI _2.46, 7.43; p = 0.32) were not significant (Supplementary 2). The interaction between ISS below and above 15 over time was also not significant for PCS (β _2.10; 95%CI _5.98, 1.77; p = 0.29) and MCS (β 0.13; 95%CI _3.94, 4.20; p = 0.95) (Supplementary 3).

Table 2 Association of variables with upper good recovery (GOSE = 8) at 5 years in 119 patients completing follow-up

	Reference	Odds ratio (95% CI)	P value
Age >65	**Age <65**	**1.402 (0.570-3.446)**	**0.462**
Male	**Female**	**0.725 (0.310-1.698)**	**0.459**
Blunt trauma	**Other types of trauma**	**0.433 (0.076-2.463)**	**0.346**
ISS >15	**ISS <15**	**0.476 (0.226-1.005)**	**0.052**
Change in PCS (1 year- baseline)		**1.064 (1.023-1.108)**	**0.002**
Change in MCS (1 year -baseline)		**1.039 (1.010-1.069)**	**0.008**
Change in PCS (2 year- 1 year)		**1.072 (1.007-1.142)**	**0.030**
Change in MCS (2 year- 1 year)		**1.005 (0.968-1.044)**	**0.781**
Change in PCS (5 year- 2 year)		**1.009 (0.969-1.052)**	**0.652**
Change in MCS (5 year- 2 year)		**0.967 (0.933-1.002)**	**0.067**

Table 3 Health status measured from 1 to 6 months, 6–12 months, 1–2 years, 2–3 years, 3–4 years and 4–5 years after injury using linear mixed effects model analyses.

	PCS*			MCS*		
	Mean difference (SE)	**95% CI**	**p**	**Mean difference (SE)**	**95% CI**	**p**
1-6 months	**4.28 (1.05)**	**2.19, 6.36**	**<0.01**	**6.46 (1.28)**	**3.91, 9.00**	**<0.01**
6-12 months	**2.47 (0.68)**	**1.14, 3.79**	**<0.01**	**0.57 (1.01)**	**1.44, 2.57**	**0.58**
1-2 years	**0.54 (0.74)**	**0.92, 2.01**	**0.46**	**0.69 (1.09)**	**1.47, 2.85**	**0.53**
2-3 years	**0.34 (0.68)**	**1.69, 1.01**	**0.62**	**0.66 (0.91)**	**1.14, 2.46**	**0.47**
3-4 years	**0.25 (0.45)**	**0.64, 1.14**	**0.58**	**1.06 (0.66)**	**0.24, 2.35**	**0.11**
4-5 years	**0.35 (0.70)**	**1.72, 1.03**	**0.62**	**0.50 (0.94)**	**1.35, 2.35**	**0.59**

Fixed effect: time points. Random effect: patient variability. Covariance structure: Scaled Identity. * positive mean difference indicate improvement over time where higher scores indicate better health status.

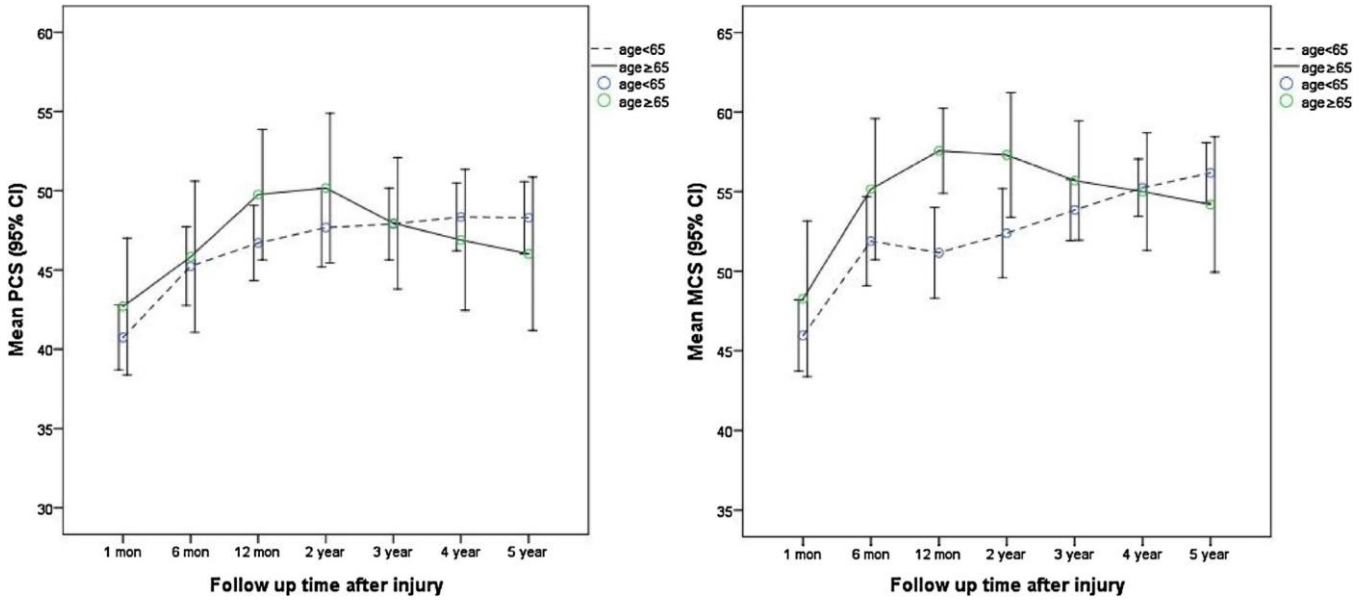

Fig. 3. Graphical presentation of physical component score (PCS) and mental component score (MCS) (mean, 95%CI) changes over time by age group in 119 patients completing follow-up.

Discussion

This is the first study to our knowledge to track health status and functional recovery up to five years after injury for moderately and severely injured Chinese patients. We found that the recovery to the level of upper good recovery, which means the resumption of normal life (with no reduced capacity to work, and resumption of full social and leisure activities), continue to improve for up to five years. The improvement of the PCS was significant for the first 12 months, but at five years our mean PCS were still well below the Hong Kong population norm of 52.83. The MCS only had statistically significant improvements over the first six months, and at five years our mean MCS was above the HK norm of 47.18.

The successful follow up rates are less than those reported by Gabbe et al and Overgraard et al, where the loss to follow up rate ranged from only 7% to 31% after three to nine years post injury. The Victorian State Trauma Registry (VSTR) cohort reported that younger, less seriously injured and those injured in intentional events were less likely to participate in their longitudinal study.

The VTSR cohort also found continued improvement to 36 months was only present for the usual activity item in EQ5D, with the risk of reporting problems with pain and discomfort increasing from 24 to 36 months. Whereas the Danish cohort showed that scores for all eight SF-36 domains were lower than the non trauma Danish controls at nine years. They found that patients with inpatient stay for more than five days, and those who received surgery during their initial hospital admission, scored significantly lower SF-36 scores especially for the four PCS domains.

MacKenzie et al also reported long term disability with a seven year follow up study with patients with lower limb trauma. Using the Sickness Impact Profile, they found that half of their patients had a physical SIP subscore of less than or equal to ten points, signifying substantial disability. They found only 34.5% had a score typical of the general population with similar age and gender.

We were not able to explain the more rapid improvement of the MCS score, and especially the higher mean than the HK norm at five year. A similar pattern has not been identified from the international literature. Gunning et al reported the one year PCS and MCS to be 45.6 and 47.2 respectively for their 1870 patients

admitted to University Medical Center Utrecht, Netherlands. They found that age, ISS, hospital LOS, ICU LOS, RTS, Ps, and severe injury to the head and extremities were associated with the SF-36 results.

MacKenzie et al have previously looked at the SF-36 from 1230 patients one year after injury, and found all eight components scored lower than the general population. However, the drop in two of the MCS components including vitality and mental health were not statistically significant. They also found the extra dimension of the cognitive function scale, which is independent of the other eight dimensions from SF-36, but affecting more of the MCS than the PCS for those with traumatic brain injury.

However, given our wide confidence intervals and the large variety of case mix in our study cohort one should not interpret the MCS result with relation to the burden of mental health issues and post-traumatic stress. Wu et al found a significant proportion of patients with PTS symptoms after relatively minor injuries in Hong Kong. Further studies looking at the mental health burden will be essential.

Limitations

There were a few limitations in this study. We acknowledge that the sample size is relatively small with patients with various baseline and injury profiles. This study focused on the 119 surviving respondents at five years, rather than the 400 patients initially recruited. Furthermore, there were up to 16% missing responses at various time points, and 5–20% of the completed responses were interviews with proxy rather than the patient themselves. These may have introduced bias. We did not study the effect of socioeconomic status, educational level or compensation all of which may affect recovery. Future studies with larger sample sizes will allow us to look into the various injury profiles and its correlation with functional outcome and health status in the longer term.

In this current study we have focused on the mean trajectory of the initial cohort of 400 patients we recruited. Given the relatively wide 95% confidence intervals, we acknowledge that not all patients recover with the same trajectory and it will be useful in the future to understand the recovery patterns for those outliers with relatively good or poor trajectories. The relative improvement in GOSE distribution with time maybe a reflection of differential survivorship, and again a larger cohort will allow us to determine the recovery trajectory with confidence.

Lastly we also recognise that the low follow up rate that may be a concern for responder bias as previously mentioned. However, given the similar profile of the baseline characteristics of the responders and non-responders, we believe that the results were representative of the cohort of patients recruited and that it represents a landmark study for quality of survival in Asia and for Chinese patients.

Conclusions

After injury, the most rapid improvement in PCS and MCS occurred in the first six to 12 months, but further recovery was still evident for MCS in patients aged under 65 years for up to five years. Further long term follow up studies with larger sample size and more comprehensive sociodemographic information is needed for the Chinese population in Asia.